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ROCK BORING DEVICE

The present invention relates to a rock boring device for creating bore holes in rock.

Boring of holes in rock faces can be conducted in a variety of ways. For example, explosive boring, as the name suggests, involves drilling in the rock face a central primary hole and a series of secondary holes about the primary hole. The secondary holes have a diameter suitable to receive an explosive charge, while the primary hole provides an opening in the rock towards which cracks that are formed in the rock after detonation of the explosive, can propagate. The primary hole is normally of a greater diameter than the secondary holes. Cracks that propagate from the secondary holes to the primary hole create rock chips or segments, that can be separated from the rock being bored and which are thereafter removed, leaving behind a bore hole. The size of the bore hole required, determines the number of primary and secondary holes needed, while each explosive detonation can only remove a certain amount of rock, so that the above process may have to be repeated several times to form a bore hole of sufficient cross-section and length. As can easily be appreciated, this method of boring can be quite dangerous due to the use of explosive material, while it is also time consuming and complicated to prepare the primary and secondary holes in the rock face. Additionally, detonation of the explosives is a skilful exercise, as each explosive is detonated separately and at different times, to achieve the greatest extent of crack propagation.

A different form of rock boring involves the use of roller cutters that are rotationally forced into impact with a rock face, to again create cracks that propagate through the rock. The roller cutters employ a plurality of cutting tips, arranged at a variety of different diameters, which are forced into engagement with the rock surface adjacent one another, so that cracks formed by one cutting tip propagate and intersect with cracks formed by an adjacent tip, thus creating a rock chip or segment that can be separated from the rock under the impact of the roller cutter. Boring devices of this kind are subject to immense

impact loading because the cutting tips are forced into engagement with the rock under immense load in order to generate the cracks in the rock and thus the rock boring device is required to have facility for large impact absorption. The impact absorption is provided by way of a huge absorption mass attached to the device and the mass is of such a size, that known boring devices can weigh upwards of 200t, a substantial component of which is for impact absorption. As a consequence, the weight and size of these devices makes them expensive to construct and operate.

It is an object of the invention to overcome, or at least alleviate one or more of the disadvantages associated with prior art boring devices. It is a further object of the invention to provide a boring device of a rotary cutting type, that provides improved rock removal from a rock face to form a rock bore and which is relatively economical to manufacture and operate.

A rock boring device according to the present invention includes a rotary disc cutter, that in use, is inserted into a pilot opening formed in the rock face and which is driven to engage the walls of the opening and to remove rock from the walls to expand the opening and thereby to progressively enlarge the pilot opening to the size of bore required. The boring device is characterised in that the disc cutter is driven in an oscillating and nutating manner. That motion, when applied to the walls of the opening, will cause the disc cutter to apply a force to the walls that promotes cracks which propagate toward the rock face adjacent the opening. By this mechanism, rock segments can be separated from the rock when a crack propagates from the wall of the opening to the adjacent rock face. Advantageously, the nutating motion of the disc cutter also tends to promote separation of the rock segments from the rock face.

A rock boring device according to the invention principally will bore through rock by generating cracks in the rock and separating rock segments formed by the cracks. However, rock normally will also be removed by the abrasive action of the cutting tips against the rock and the nutating motion of the disc cutter against the rock will also facilitate removal of rock in this manner. However, the amount of rock removed by this mechanism is relatively small.

The disc cutter of the boring device preferably has a circular, rock engaging periphery, and preferably includes a plurality of cutting tips which are removably connected to the cutter. Preferably, those tips extend from the disc cutter at or adjacent to the circular periphery thereof, either radially, axially, or in a combination of both. The cutting tips can be formed of any suitable material, such as tungsten carbide or hardened steel, depending on the type of rock being bored. They can also have any suitable shape and can be fixed to the disc cutter in any suitable manner.

The oscillating movement of the disc cutter can be generated in any suitable manner (FURTHER INFORMATION IS REQUIRED - SEE PAGE 6 LINE 8)

The disc cutter is driven in a nutating manner simultaneously as it oscillates. The same drive may facilitate both the oscillating and nutating movement, or a separate drive may be provided for both. In a preferred form of the invention, the nutating movement is achieved by mounting the disc cutter on a drive shaft along an axis slightly offset from the longitudinal axis of shaft. For this arrangement, the disc cutter may be mounted on one end of the shaft, which end extends from the shaft at an angle offset from the longitudinal axis of the shaft. The offset end may be formed integral with the shaft, or may be attached thereto and the end may include means to attach the disc cutter thereto. Those means may fix the disc cutter relative to the end, or may allow for relative movement therebetween. The disc cutter may for example, be mounted on the shaft end by bearings, such as thrust bearings, to allow relative rotation therebetween.

The drive shaft may be rotatably mounted in a housing and the housing may include impact absorbing means for absorbing impact loads exerted on the disc cutter by boring engagement with the rock. The impact absorbing means may take any suitable form, and in one form includes a mass attached to the housing. The mass is preferably concentric with the drive shaft and preferably is formed of a plurality of plates arranged side by side lengthwise of the shaft. The plates are preferably metallic and in one arrangement a plurality of iron or

steel plates are fixed together, with one or more lead plates interposed between adjacent iron or steel plates.

The boring device of the invention is not restricted to a single disc cutter, but can include more than one. For example, the boring device may include three disc cutters arranged along the same plane, but at approximately 45° to each other. Such an arrangement can produce a bore of a particular shape, while the speed at which rock is removed is greatly increased. In this arrangement, each of the three disc cutters can be driven by the one drive means, or they may be driven by separate drive means.

Alternatively, the disc cutter may be mounted on a movable boom, to enable the disc cutter to be moved about the pilot opening as that opening is enlarged. In this arrangement, the housing and absorption mass (if provided) may also be mounted on the boom.

In still a further arrangement, a pair of disc cutters may be mounted on separate booms and the disc cutters are swept in an arc across the rock face, continually removing successive layers of rock from the face.

The attached drawings show an example embodiment of the invention of the foregoing kind. The particularity of those drawings and the associated description does not supersede the generality of the preceding broad description of the invention.

Figure 1 is a cross-sectional view of a boring device according to the invention. The boring device 10 includes a boom assembly 11 and a rotary disc cutter 12. The boom assembly 11 includes an elongate shaft 13 that is rotatably mounted within an impact absorbing housing 14, that is formed of heavy metal. The shaft 13 is mounted within the housing 14 by a plurality of thrust bearings 15, which can be of any suitable thrust capacity. The thrust bearings 15 are mounted in any suitable manner known to a person skilled in the art, such as between stepped sections 16 and 17.

The housing 14 can have any suitable construction, and in one form includes a plurality of metal plates fixed together longitudinally of the shaft 13. Such an arrangement is shown in Figure 2, and with this arrangement, applicant has found that a plurality of iron plates 18 and a single lead plate 19

provides effective impact absorption based on weight and cost considerations. It is proposed that the lead plate 19 be disposed between the forward end iron plate 18a and the iron plate 18b.

The shaft 13 is mounted for oscillating motion about a central longitudinal axis AA and the radius of oscillation will typically be in the order of 5-10 mm, although it may of course vary from this to suit different conditions. The oscillating motion can be achieved in any suitable manner and in the present invention, it is achieved by ELECTRIC MECHANICAL OR HYDROSTATIC TRANSMISSION

The nutating movement of the disc cutter, occurs simultaneously with the oscillating motion and that movement is movement in which a point on the cutting edge of the disc cutter is caused to move from a forward to a rearward position and back, in a cyclic or continuous manner as the disc cutter rotates. Thus, the disc cutter can be arranged to apply an impact load to the rock surface which has components directed both perpendicularly and rearwardly of the surface. Such a load tends to promote cracks in the rock that extend from the rock surface under boring load, to the adjacent rock face, so that chips of rock can be removed. This arrangement is illustrated in Figure 3, in which a rock face 20 is being bored by a boring device 21. The disc cutter 12 of the boring device 21 is inserted into a prepared pilot hole which is formed in the rock face 20. The diameter of the pilot hole is slightly greater than the oscillating diameter of the disc cutter 12 and the depth of the pilot hole can be in the region of 50-100 mm. The pilot hole is formed normally by known drilling machinery.

The construction of the boring device will be described in more detail later, but from Figure 3 it can be seen that the motion of the disc cutter 12 brings the cutting tip or edge 22 into engagement under the oscillating movement with the under face 23 of the rock face 20. Such oscillating movement results in travel of the disc cutter 12 in a direction substantially perpendicular to the axis AA. The oscillating movement will promote cracks in the rock that will extend largely parallel to the rock face 20. However, the provision of simultaneous nutating movement causes the cutting edge 22 to

strike the f[illegible] 23 substantially in the direction s[illegible] that the cracks 24 formed in the rock propagate toward the rock surface 20.

When the cracks 24 reach the rock surface 20, the section of rock defined between the crack and the rock surface will be separated from the rock by the impact of the disc cutter. The advantage of the oscillating/nutating movement, is that rock segments are broken away more easily from the rock face than with oscillating movement alone, because the induced cracks propagate in a more direct line to the rock surface 20 and the nutating motion of the disc cutter promotes lifting or separating of the rock chips away from the rock face.

Referring back to Figure 1, the disc cutter 12 of the boring device 10 includes a plurality of cutter inserts 25 spaced about the periphery of the disc cutter 12. The number of cutter inserts 25 spaced about the periphery will vary depending on the diameter of the periphery of the disc cutter 12 and the type of rock being bored. However, for a periphery of 300 mm diameter, it is envisaged that around 40 cutter inserts will be employed. The cutter inserts 25 can be made from any suitable material, such as tungsten carbide, although different cutter inserts may be employed for different types of rock, which may vary in hardness and abrasiveness.

The disc cutter 12 includes a cap section 26, that is attached in any suitable manner to a cutter head 27, such as by threaded bolts. Attachment in this manner allows the cap section 25 to be released from the cutter head for maintenance purposes, such as for repair or replacement of cutter inserts.

The cutter head 27 is rotatably attached to the neck end 28 of the shaft 13 and it can be seen that the neck end is angularly offset from the longitudinal axis AA by an amount α. By this attachment, the cutter head 27 and the cap section 26 are rotated in a nutating manner upon rotation of the shaft 13. For rotatably mounting the cutter head 22 to the neck end 28, a thrust bearing 29 is employed, although other kinds of bearings may be equally appropriate.

Drive of the cutter head 27 relative to the neck end 28 of the shaft 13 is by way of [illegible] ON THE [illegible] A FLEXIBLE COUPLING FROM THE INPUT DRIVE

The cutter head 27 is arranged to seal against the housing 14 and while this is not shown in Figure 1, Figure 4 shows this arrangement clearly. In Figure 4, the front end 30 of the housing 14 includes a sealing face 31 against which a sealing face 32 of the cutter head sealingly engages, by virtue of a seal 33 disposed in a recess 34 formed in the sealing face 32. The seal can be any suitable seal, such as a ELASTOMER and it can be fitted in any suitable manner. The seal 33 is to prevent ingress of rock chips, dust and the like into the interior of the boring device.

The present invention can be applied to a wide variety of boring devices and one such device is shown in Figure 5. In this figure, the boring device 100 is pivoted on a boom so that he disc cutter can be manoeuvred about the boom pivot point to create a bore in a rock face.

Figure 6 shows a different arrangement in which three disc cutters extend from the boring device 200 and these cutters are aligned along the same plane and are oriented at an angle to each other, the angle being approximately 45°. Each of the disc cutters is arranged for oscillating and nutating movement as previously described.

Figure 7 shows an arrangement of two boring devices 300 and 400 which pivotally arranged on respective booms 301 and 401 (such as that shown in Figure 5), and in which the disc cutter 302 and 402 of each device is arranged to sweep in an arc across the rock face 500 being bored in a first direction D_1 and having completed that sweep, return in the reverse direction D_2, with each sweep of the disc cutters removing a layer of the rock face 500. This method provides a bore 501 as shown.

The boring device of the present invention is considered to provide more cost efficient rock boring, because the device can be built at a fraction of the weight of known rotary boring machinery. It is envisaged that the boring device of the invention can be manufactured to have a total weight of approximately 20t. This means that the device will be far cheaper to manufacture and run compared to the known rotary boring machinery. The weight reduction is principally due to the enhanced boring which results from the combination of oscillating and nutating movement of the disc cutter. Thus, the boring device is

subject to reduced impact loading and therefore requires substantially less facility for impact absorption.

The invention described herein is susceptible to variations, modifications and/or additions other than those specifically described and it is to be understood that the invention includes all such variations, modifications and/or additions which fall within the spirit and scope of the above description.

20 JAN 1999.

Fig 1

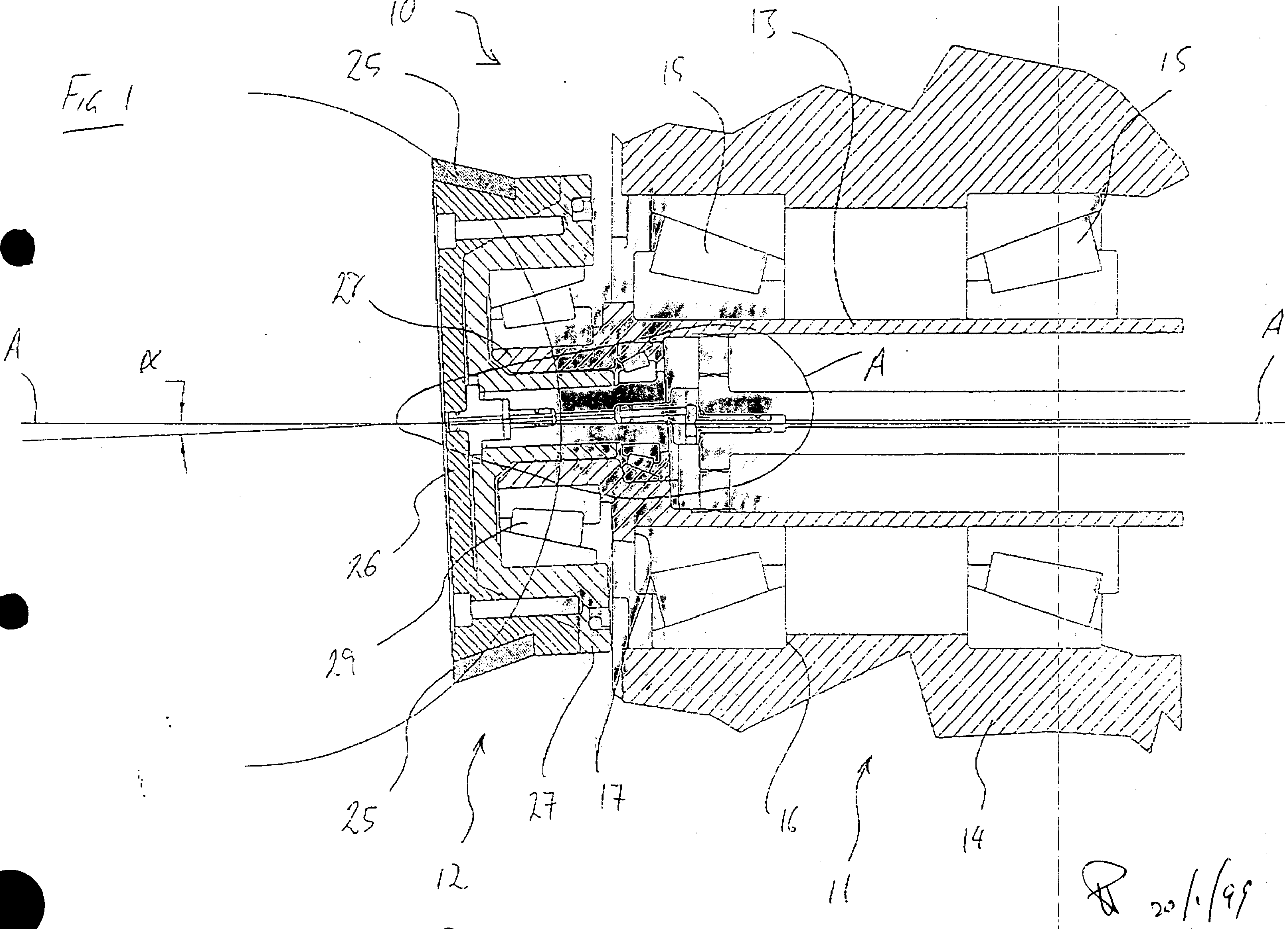

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FIG 2

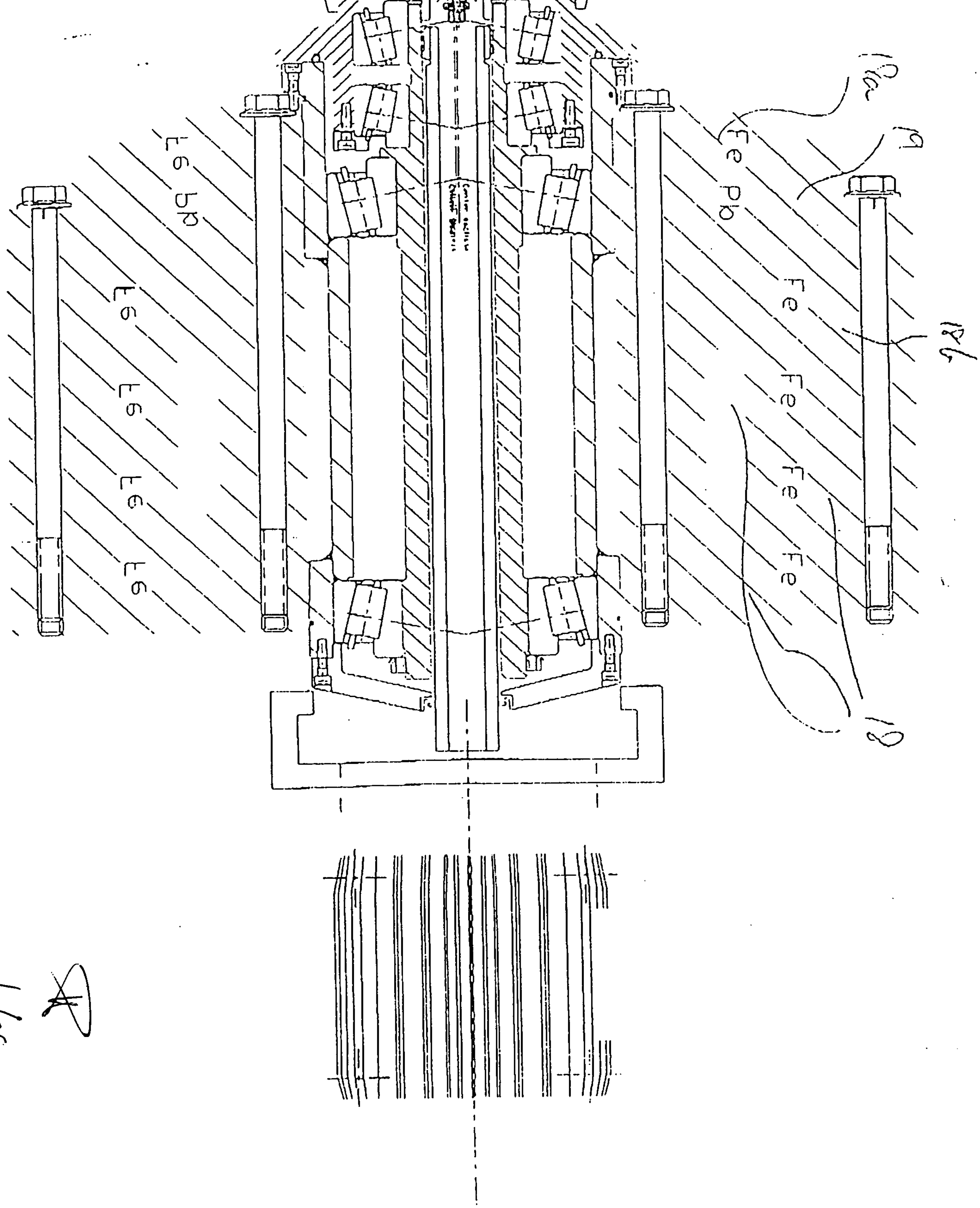

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FIG 3

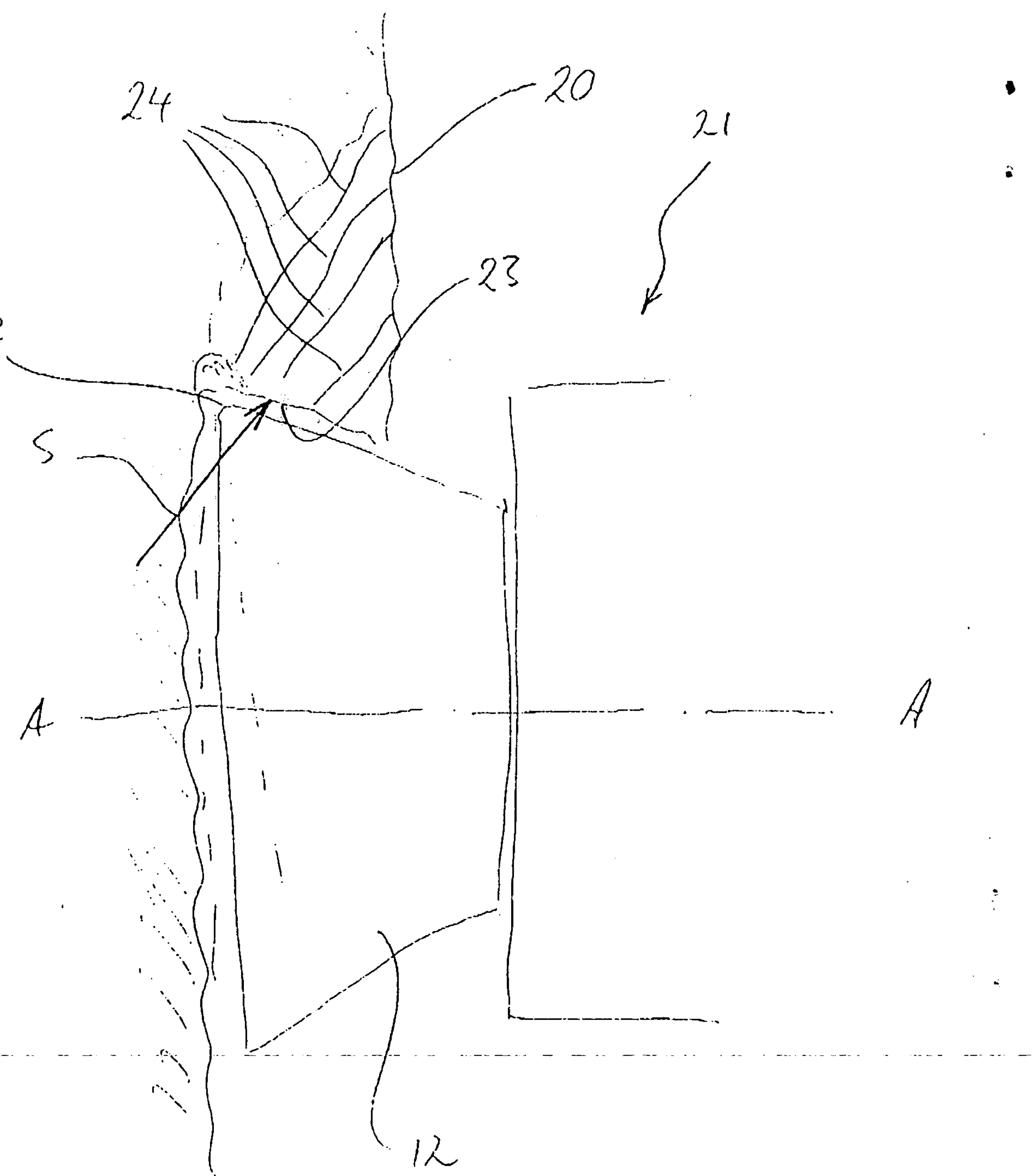

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FIG 4

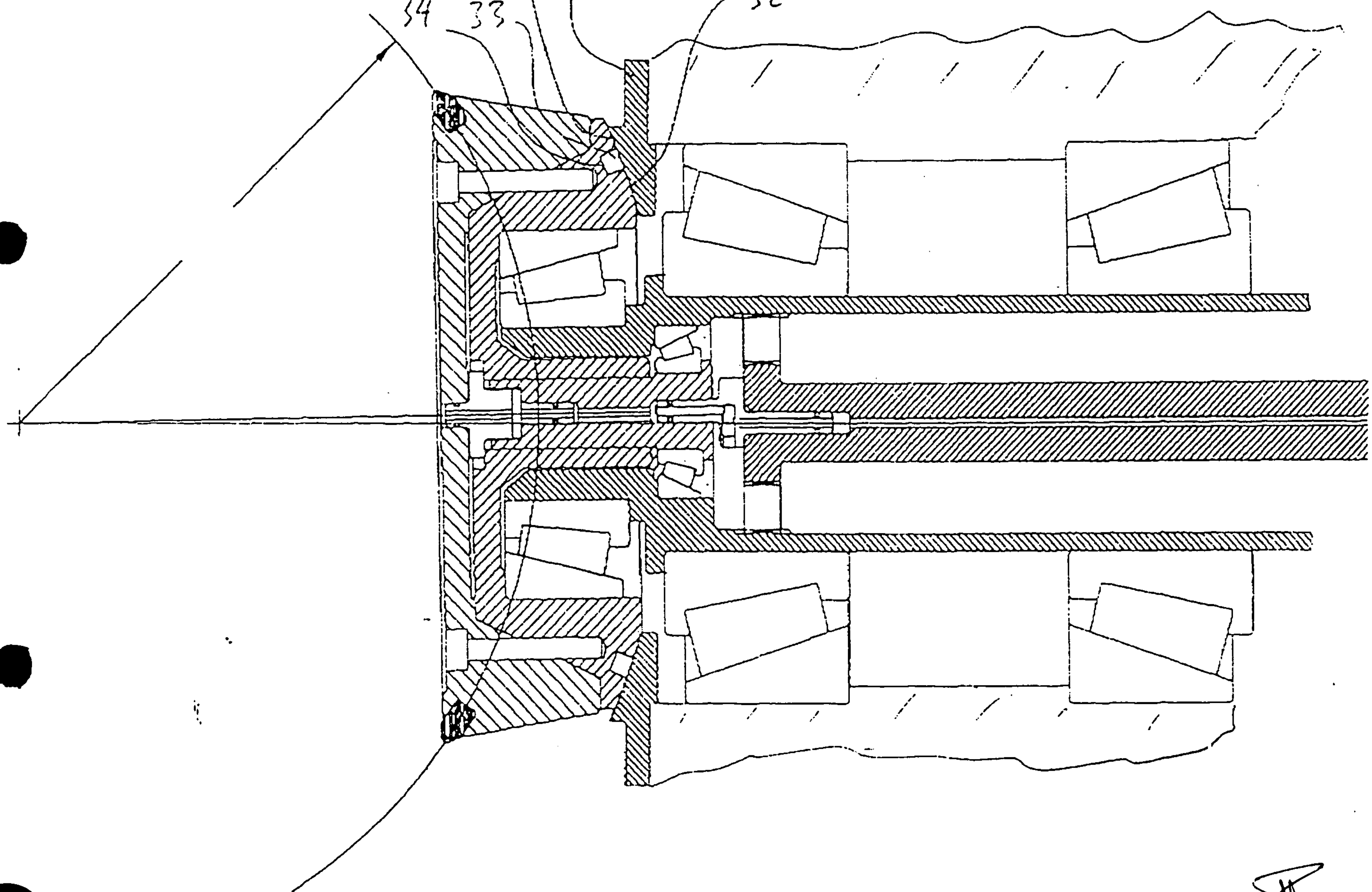

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FIG 5

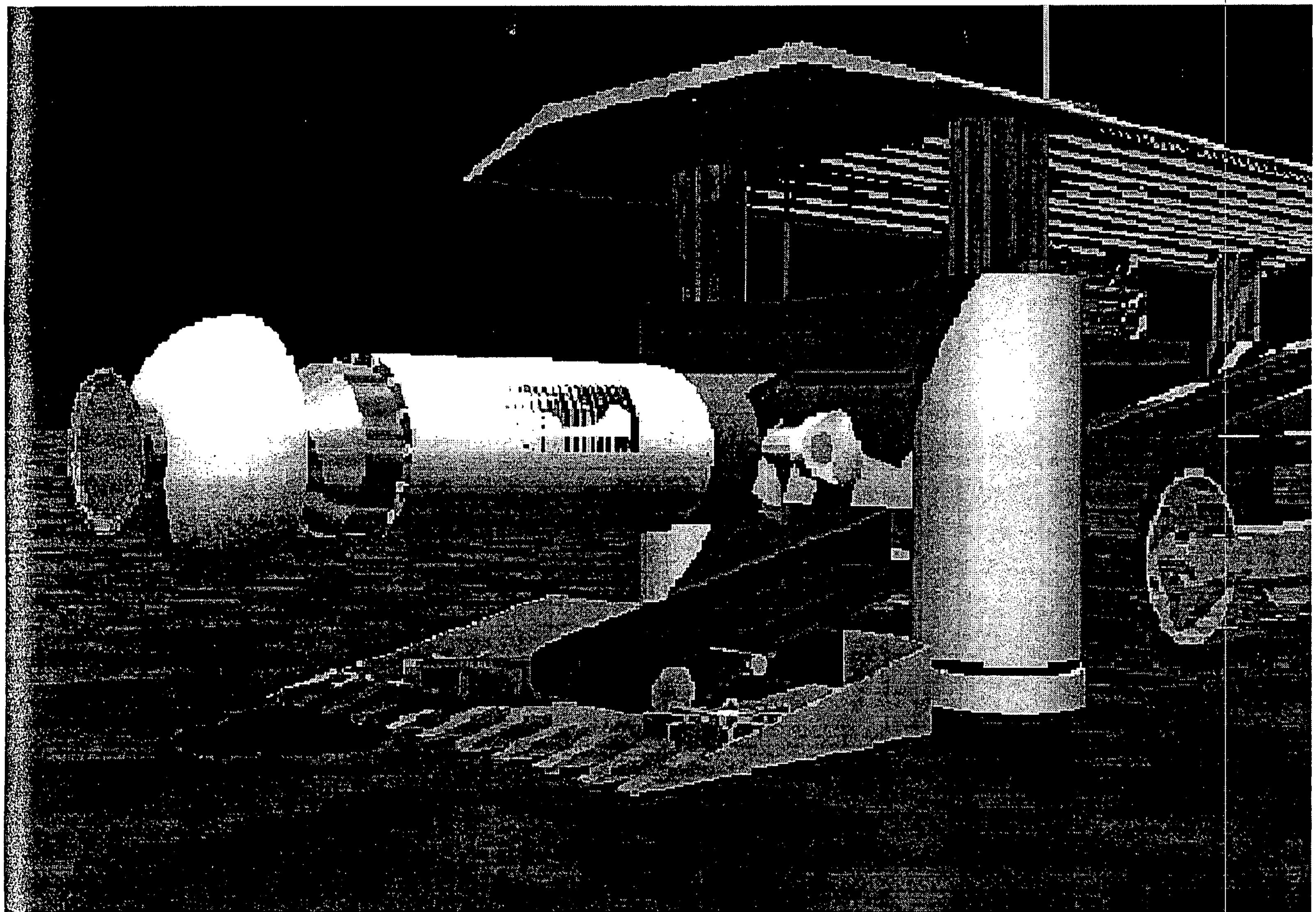

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Fig 6

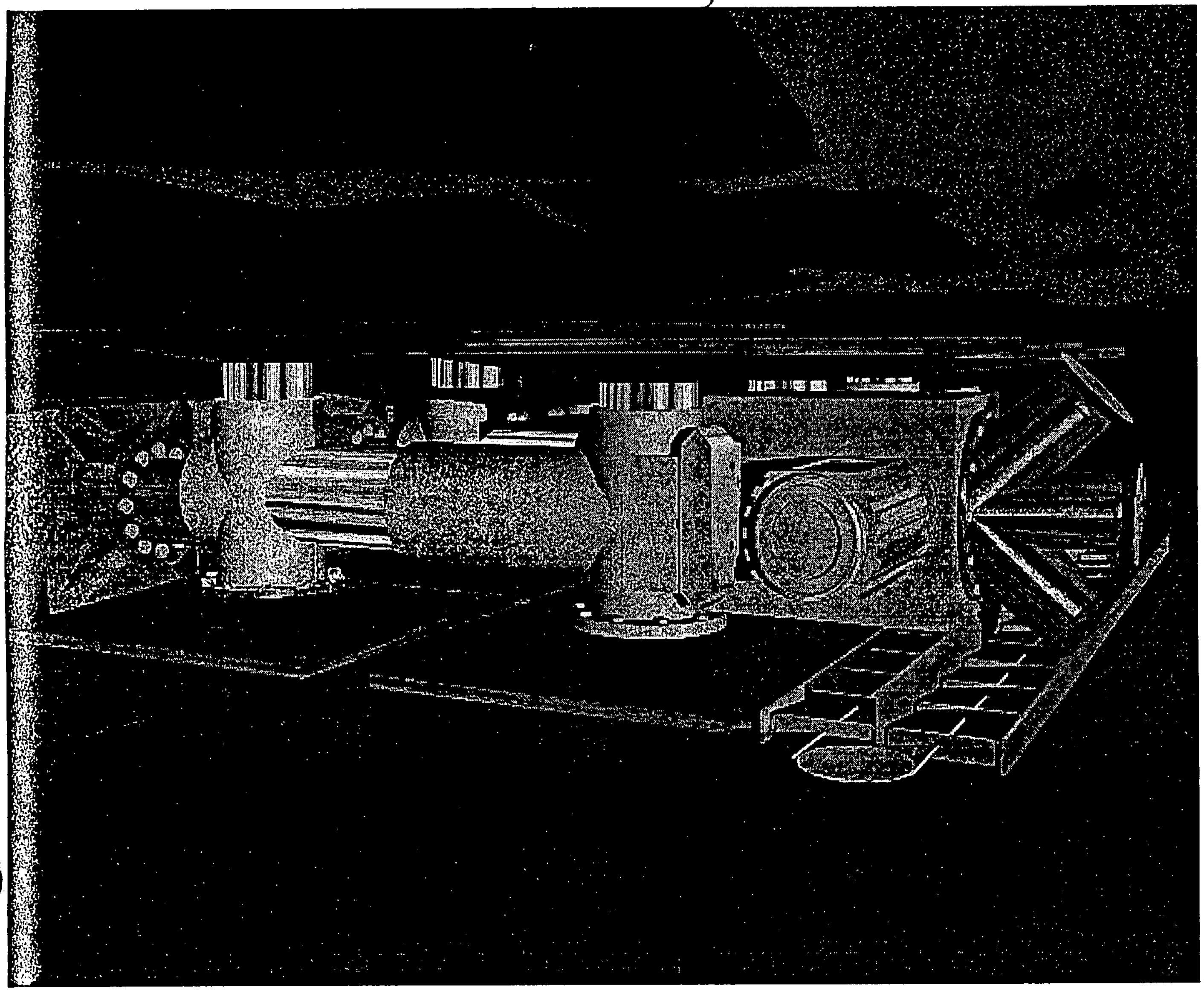

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FIG 7